

Utah Science

Volume 36 | Number 3

Article 1

9-1975

Utah Science Vol. 36 No. 3, September 1975

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Recommended Citation

(1975) "Utah Science Vol. 36 No. 3, September 1975," *Utah Science*: Vol. 36 : No. 3 , Article 1.
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COSTLY SUBDIVISIONS

COYOTES AND DEER

UTAH'S WATER

Agricultural Experiment Station
Volume 36 Number 3

UTAH SCIENCE

In a mathematical model, investigators in USU's Department of Economics determined that one of the best developed subdivisions in Utah will cost its county government over half a million dollars before it begins to pay its own way. The model did not include such nonquantifiable factors as environmental impacts and aesthetics. Report on page 83.

Coyote predation is always a hot topic in Utah, a topic which includes the question of whether this predation is really a problem. Darwin Nielsen found in a study of his own that coyotes were indeed a problem for a deer herd in Cache County, Utah, last winter. Nielsen's report is on page 87.

The nematode problem in Utah is not confined to alfalfa but attacks crops growing in rotation with it – onions, sainfoin, tomatoes, and beets. Gerald Griffin reports his findings on page 90.

Prescribed burning of pinyon-juniper at the Park Valley Demonstration Ranch netted researchers a lush stand of crested wheat grass and a lot of useful data on how to do it. Ralphs, Schen, and Busby describe the process on page 94.

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Omission:

The photo of the wagon on the June 1975 issue of **Utah Science** was taken by John P. Workman.

UTAH SCIENCE

A quarterly devoted to research in agriculture, land and water resources, home and community life, human nutrition and development, and other wide-ranging research conducted at Utah State University. Published by the Agricultural Experiment Station, Utah State University, Logan, Utah 84322.

The magazine will be sent free on request.

To avoid overuse of technical terms, trade names of products or equipment sometimes are used. No endorsement of specific products or firms named is intended, nor is criticism implied of those not mentioned.

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Subdivisions out in the county can be expensive

James L. Thompson, Paul A. Randle, and C. M. McKell

Subdivisions in unincorporated areas require costly community services such as schools, road maintenance, police and fire protection, and health services. Because of the need for such services, subdivisions can cost a county considerable sums of money. They can also deprive local governments of income derived from agricultural production and the agricultural industry may be severely hampered in its efficiency. Additionally, open space is lost when urban sprawl takes place.

Urban sprawl also creates serious economic problems for existing agriculture. One of these is the inflated value often imposed on adjacent agricultural lands when a land parcel sells for a price higher than its value for producing agricultural crops. Eventually agriculture is not able to survive the economic strain of the high tax rate.

Environmental resources may also be endangered with the urbanization of unincorporated areas. Pollution or physical damage to watersheds can occur where housing, vehicle traffic or sewage disposal does not consider minimum limitations. Wildlife habitats may be sufficiently altered by man's presence to make them unsuitable for certain species of animals. The scenic beauty of once unspoiled landscape may be degraded by the presence of structures, roads, and clearings.

Another problem which is difficult to assess, but nevertheless can be a serious one, is the change of social structure when urban dwellers and short-term out-of-state residents move into rural areas. Parties on both sides will find that their traditional values will come into some degree of conflict.

Development Pressures

What causes the demand for development in unincorporated areas? The basic factor is Utah's relatively high growth rate which in 1973-74 saw fifteen counties with population increases up to 5 percent and seven with growth over 5 percent. Only seven counties experienced no growth.

This growth along with the demand for recreation homes places extra heavy demands on county officials charged with maintaining economy in the operation of county government and its services along with an orderly program of development. The efficiency with which community services can be supplied is almost always greater within the incorporated bounds of cities rather than counties. Thus, city officials should seek to develop vacant areas within their boundaries or annex adjacent areas which would concentrate the provision of community services as much as possible. When cities fail to recog-

The Summit subdivision can provide an example of the costs and benefits which are likely to accrue to a county over time as a result of new subdivision development



nize their opportunities, and sometimes responsibilities, to accommodate population growth, the pressures often fall upon unincorporated areas of counties. The resultant developments create high per unit costs for county governments.

Dust Off County Master Plans

When faced with subdivision rezoning requests, county officials would do well to refer for guidance to the county master plan and its goals and policies. Since a county master plan is usually based on a set of goals that have been agreed upon by the citizens, they ideally reflect the values and aspirations of people residing in the county. Intrusion of urban-type subdivisions into unincorporated agricultural areas, watersheds, or scenic locations often run counter to some of the goal statements. For example, in the Cache County Master Plan (1968) some of the key goals and policies emphasize maintenance of a strong agriculture: 1) Preserve prime and good farm land for agriculture, 2) Encourage development of agriculture-based industry, 3) Do not extend public services into areas where they are not feasible, 4) Preserve natural drainage channels to prevent damage from storm run-off, 5) Local governments should not provide unnecessary public services in small towns and rural areas, 6) Incorporated cities should maintain their geographical identity, and 7) Locate developments in areas where adequate public services are available. The foregoing policies and goals have been a helpful guide for decisions on rezoning requests in Cache County.

Financial Impact of a Subdivision May be Considerable

Many elected officials are not fully aware of the hidden costs inherent in placing a subdivision in a location distant from existing community services or where no

previous development has taken place. Many years may pass before the taxes collected from a subdivision finally balance the costs to the county for providing public services — indeed in some cases the costs may never be fully repaid. Thus, in small counties where budgets are extremely tight and existing services may already be on a marginal basis, increased demand for public services could well bring a dilution of services or a serious financial burden to the county. Rezoning and development that promotes a “high quality” subdivision may create an additional tax burden, which for a period of time, must be shared among the existing property owners in the county.

A study of the Summit Park subdivision in Summit County, Utah, provides a representative example of the costs and benefits realized by the county from the development of a quality subdivision. Summit Park is located just off Interstate 80 at the top of Parley's Canyon east of Salt Lake City. This subdivision is not a “typical” mountain subdivision, but is one of the best developed in Utah with carefully contoured and oiled roads, an adequate water supply, year-round access and occupancy, and homes ranging in value from \$10,000 to \$100,000. Approximately 550 lots have been sold, with another 500 to be developed at the rate of 100 a year. Approximately 100 families have built homes and are presently living in Summit Park. As originally planned, Summit Park was to be a community complete with a business district. However, the rerouting of Interstate 80 through the proposed business district left only one gas station and a cafe.

A previous study indicated that, “once a few homes are built owners are likely to pressure the county for streets and urban services” (Johnson 1972). Presently, Summit Park

Summit Park subdivision is not a “typical” mountain subdivision, but is one of the best developed in Utah.

is the only Summit County subdivision in which the county has taken over the maintenance of the roads, among other services. Thus, Summit Park can provide an example of the costs and benefits which are likely to accrue to a county over

time as the result of new subdivision development.

To determine the net value to a county from a new subdivision, the following mathematical model was developed:

$$\frac{R_1 + \sum_{N=1}^N T[L_1 + A + \sum_{j=1}^N P(1+G_1)^{j-1}(Q_1)] + F(Q_1) + I(1+G_2)^N(H)(B_1+NQ_1) - T(U_1) - C(1+G_3)^N(H)(B_1[NQ_1])}{(1+i)^N}$$

While the mathematics appear formidable, the model simply provides a matching of revenues resulting from subdivision and costs of providing services to the subdivision over time. If the model produces a positive number as an answer, the subdivision is a viable "investment" for the county to consider. If the answer is negative, revenues will never repay costs, and the subdivision, if developed, will require permanent subsidy by previous county taxpayers.

The revenue measurement components of the model are:

1. Property Tax Revenues:

$$T[L_1 + A_1 + \sum_{j=1}^N P(1 + G_1)^{j-1}(Q)]$$

Tax mill levy (T) in the future was estimated by the county clerk in Summit County to be 11 mills.

Assessed value of developed land (L) was based on estimates given by the assessor's office of Summit County and on tax records which have shown the growth rate between reassessments to be 4 percent. The beginning figure for (L) is \$680,000.

Assessed value of buildings (A) in the subdivision was based on the records and estimates given by the developer, tax records, and estimates by the county assessor.

Average assessed value of new houses built in each year of reassessment (P) is based on industry trends combined with the county clerk's and developer's estimates. (G₁), the growth rate of assessed valuation, was set at 4 percent and was determined historically from the growth rate of residential housing in the county.

The number of houses built each year (Q) is based on the developer's records and estimates and past records of subdivision buildup rates.

2. Building Permit Fees:

$$F(Q)$$

The building permit fee (F) is set by the county commission.

3. Incremental Revenues Resulting from Population Increases:

$$I(1 + G_2)^N(H)(B + NQ)$$

Certain county funds are received from state and federal governments on the basis of population. This incremental revenue is a benefit to the county. (I) is the incremental revenue per person; (G₂) the growth rate of the revenue in future years; B the total number of houses in the subdivision; (H) the number of people per house; (N) the year; and (Q) the number of homes built during that year.

The hypothesis of the county commissioner that the subdivision would be a financial asset to the community is not supported by the mathematical model

The expense measurement components of the model are:

1. Taxes lost on land developed

$$T(U)$$

Where (U) is the assessed valuation on undeveloped land.

2. The incremental costs resulting from population increases

$$C(1 + G_3)^N(H)(B_1 + NQ)$$

(C) is a per capita assignment of incremental county expenditures, and (G_3) the expected growth rate of those expenditures. The other rotation has been explained previously.

All costs and revenues were discounted to present value at the rate paid on long-term county indebtedness.

The formula required collection and extrapolation of data from 1972 to the estimated year of full subdivision buildup. 1972 was chosen as a base year because it was the most recent year for which the financial records were complete in Summit County. The next reassessment is to take place in 1976, making $R_1 = 4$ in the model. The county clerk estimated further assessments taking place every seven years, making $R_2 = 12$ and $R_3 = 19$. Complete buildup was estimated from the data to be accrued in 1996, making $R_4 = 24$.

The mathematical formula for Summit Park subdivision and Summit County was applied using the following factors:

$L_4 =$	\$2,043,379	$G_1 =$.04
$A_1 =$	\$600,000	$F =$	\$150
$A_2 =$	\$1,060,000	$I =$	\$22
$A_3 =$	\$4,000,000	$G_2 =$.04
$A_4 =$	\$11,178,000	$H =$	3
$P =$	\$8,000	$B_1 =$	100
$Q_1 =$	10	$B_2 =$	140
$Q_2 =$	30	$B_3 =$	380
$Q_3 =$	60	$B_4 =$	820
$Q_4 =$	90	$U_1 =$	\$5,900

$U_2 =$	\$8,260	$C =$	\$72
$U_3 =$	\$11,800	$G_3 =$.04
$U_4 =$	\$17,700	$I =$.05

Using the above factors, the Net Present Value of Summit Park subdivision to Summit County from 1972 to the estimated year of full buildup was shown to be -\$539,086. The hypothesis of the county commissioners that the subdivision would be a financial asset to the county is not supported. Instead, with its existing tax and fee control techniques, the county government is subsidizing the developer and buyers, possibly promoting further development (and expenses).

The limitations of the cost analysis are that it fails to include all nonfinancial factors (nonquantifiable) such as impact on the environment, the aesthetics of continued rural sprawl, and unforeseeable variables could drastically modify the future that is predicted. Nevertheless, the precautions that were taken seem to bear out a general acceptance of the conclusions drawn.

What To Do

County officials facing decisions about the development of subdivisions should carefully analyse the incremental costs of providing the necessary community services. Even if a waiver of the provision of services is granted initially, subsequent transfers of properties and social pressures will require counties to make additional expenditures for the subdivisions.

The most economical way to provide new housing may be to confine developments to existing communities or to extend such communities. The amount of land annexed should not exceed immediate needs or those specifically anticipated through a master plan.

City and county officials should work closely together to anticipate long-term housing and recreation needs in their areas and then adhere to policies that will main-

tain land productivity, open space, and enhance community identity and community goals. Certainly the costs of putting any subdivision or development in an unincorporated area should be carefully examined from a long-term point of view. Areas of potential development should be identified and advanced planning instituted that will provide guidance to those who wish to develop.

Citizens should become acquainted with county master plans through various processes of involvement and communication. County land use goals should be periodically reevaluated to properly reflect the changing values of the residents and the county's relations to adjacent areas. Prime agricultural lands should be given a high priority to protect their long-term productivity for the benefit of society.

References

Cache County Master Plan. 1968.

Johnson, Morris E., *Utah's Subdivision Problem*, Environment and Man Program, Utah State University, Logan, Utah, 1972.

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The birds,
animals & flowers
are dying to tell us...
"Give a hoot,
don't pollute."



Join Woody Owl's fight against pollution. Today.

UTAH SCIENCE

Most of the preconceived ideas I had about coyote predation on deer proved to be false

COYOTES AND DEER

Darwin B. Nielsen

There are many popular assumptions concerning the coyote-deer predation problem: coyotes cannot kill deer; coyotes do not kill healthy deer; occasionally coyotes will kill a deer; coyote predation on deer herds is not significant in the overall deer population dynamics. It seems like almost everyone interested in the environment or in wildlife management has the coyote-deer, predator-prey relationship solved. Yet empirical evidence backing up any of their contentions is quite difficult to find.

Studies have been done in Utah and other states to verify predation losses of domestic livestock to coyotes, especially in the coyote-sheep predation problem. James E. Bowns, Range Scientist connected with USU, has conducted a study of this type in the southern part of the state and would occasionally find a deer killed by coyotes. We decided to survey coyote-deer predation on opposite ends of the state to see if some meaningful data could be collected, especially during the winter months.

Cache Deer Herd

The material reported here covers one deer wintering area in the north end of the state — Cache County, Utah. This range is located just south and east of the Hardware

Ranch. The main purposes of the study were to: (1) determine if dead deer could be located in the winter time, and (2) determine if the cause of death could be verified.

The reason for selecting this particular deer wintering area was because of a number of dead deer reported the winter before (1973-1974) by snowmobilers who visited the area. Much of the study area is open sagebrush range with rather steep canyons draining to the river. It was possible to cover a considerable amount of the area with a snowmobile.

Observations were made in the area during the winter period from December 7, 1974, to March 15, 1975, during eleven trips. It is quite possible that the study could have gone longer into the spring season but due to teaching commitments, it was terminated in mid-March. Also, the deer herd was moving off the wintering area and dispersing over a much larger area which made it very difficult to check for dead deer.

Dead Deer Evident

It became evident early in the study that dead deer could be found. It was possible to just happen onto the kill site (as evidenced

by blood and hair on the snow) in passing through the winter range; however, the most effective way of locating dead deer was to watch for bird activity.

Almost without fail, several birds on the ground or concentrated at a particular spot would indicate the remains of a deer. Magpies and bald eagles were the two dominant flesh-eating birds on the site. I saw as many as five bald eagles and 15 to 20 magpies on the ground feeding on a single deer carcass. Occasionally, this type of bird activity could not be investigated because of the steepness of the terrain and was not counted as a dead deer find. One clear, cold winter day, I attempted to estimate how many eagles there were in the vicinity and arrived at somewhere around 18 to 21. It is my contention that most of these eagles were bald eagles, since all those I saw close enough to identify were bald eagles.

Although bird activity proved to be a very reliable indicator for locating dead deer, deer carcasses are usually picked clean within 12 to 24 hours after the kill. Therefore, if an investigator were to use this method of locating dead deer, he or she would have to visit the study area a minimum of every other day.

Most of the deer found were killed in a way almost identical to the way coyotes kill sheep. From the sheep verification studies, death is usually caused by collapsing the trachea and smothering the animal to death. However, there appears to be more external bleeding with the deer. Blood stains are usually quite evident on the snow-covered kill sites.

When a dead deer was found, a photo was taken of the carcass and any other evidence that might be available, such as tracks, blood, hair, or coyote droppings. Next, more precise evidence of whether this was a coyote kill was looked for. The head and neck area was skinned to see if there were fang holes through the hide and to see if there was evidence of tissue damage and bleeding in the neck area (see Figures 1 and 2). If it were an adult deer and the carcass was such that one could make a determination, the hind legs were skinned to see if the animal had been bitten at the hock (ham string). Quite often the coyote would get hold of the deer so close to the head that he would have the deer's jaw bone in his mouth. The coyote had enough power to break the deer's jaw bone in some cases; in other cases, holes were bitten through the deer's jaw bone. On one occasion, it appeared that the deer had been taken by the nose and held. The nose was chewed off and there was a considerable amount of bleeding which indicates it was not done after the animal was dead. In this case, I found the deer so soon after the kill that it was still warm. In fact, I am sure the coyote was frightened off the kill by the noise of the snowmobile because the coyote had not fed on the deer.

During this study, 31 dead deer were located and investigated. All of these were killed by coyotes but three. These three were not killed but died from some other cause. There was a completely different appearance of the body tissues of

the deer that died as compared to those that were killed. The blood veins were full of dark colored blood and the muscle tissue seemed to be a different texture and color. Also, these carcasses were frozen to the point that it was difficult to skin the head and neck area (Figure 3).

Yearling Fawns Vulnerable

All of the 28 coyote-killed deer were last year's fawns except three. These three consisted of one two-point buck and two adult does. The buck carcass was found at the edge of a fairly wide stream which might indicate that he stopped at the stream bank and was caught by surprise. One of the adult does showed evidence of having been bitten at the "ham string" hock, but the tendon was not severed.

Since fawns from the previous spring appear to be the main prey of the coyote as far as this deer herd is concerned, the question arises, do they kill fawns because they are more tender or because they are easier to kill? I suspect the latter because my observations indicate that the coyote only eats a small portion of each deer he kills. They usually chew through the rib cage and consume the heart, liver, and other viscera in the body cavity. The birds consume the muscle tissue and remaining edible parts of the body. After the coyotes and birds finish, there is only a bit of the hide and a few bones remaining.

Most of the preconceived ideas I had about coyote predation on deer proved to be false. I assumed that coyotes worked in packs consisting of several coyotes. Based on evidence from coyote tracks in the snow, most of the kills were made by a single coyote. Although I saw many coyote tracks snowshoeing cross country on this deer range, only one time did it appear as if more than a single coyote made them. In this case, there were two

Most of the deer found were killed in a way almost identical to the way coyotes kill sheep



Photos by Darwin Neilsen

Figure 1. Tissue damage and bleeding in the neck area of dead deer.



Figure 4. Absence of snow cover in the study area.



Figure 2. Fang holes through hide of dead deer.



Figure 3. Deer dead from cause other than coyote predation. Note absence of blood at the site of death.



Figure 5. Even in snow covered areas feed was available for wintering deer.

coyotes traveling together or one following the other within a short time span. There was evidence at only one kill site that more than one coyote had been involved.

Although we have heard that coyotes need deep crusted snow in order to run deer down, it proved to be the exception rather than the rule in this study. I found tracks in crusted snow which indicates this type of chase *does* occur. In this case, the deer escaped by crossing the river. But in most of the cases I observed, there was little or any sign of a chase. In fact, it appeared that less than ten yards were covered from the time the coyote and deer tracks came together and until the deer carcass was found. The amount of snow on the ground does not even seem to be a factor influencing whether coyote can kill these deer. Some carcasses were found in relatively deep snow — (20 to 24 in.); other kill sites were out on

open ridges where the snow was all melted. The first deer which was killed by a coyote was found on December 7, 1974. The snow depth was about 18 cm. (7 in.). In this case, the deer were just entering the winter period and were in good physical condition.

Winter Not Severe

In fact, the winter up to mid-March was not severe at all in this area, and was probably one of the best in the state. It would be indeed hard to convince me that these deer were suffering from malnutrition and would probably have died anyway (Figures 4 and 5).

Coyote control was practiced by helicopter in the area and several coyotes were taken from close by. Trappers and sports hunters were also active there. I had direct report of 8 to 10 coyotes being killed

within the study area itself. But although predation on the deer herd seemed to slow after the helicopter flew the area, it did not stop.

The question remains unanswered as to how significant winter coyote predation is on deer herd populations and more study needs to be done. On the other hand, it is evident that coyote predation on deer herds does take place and that with some effort the dead deer can be found.

Darwin B. Nielsen is Professor of Economics, USU.

Stem Nematodes — their effects on plants grown with alfalfa

G. D. Griffin

The bulb and stem nematode *Ditylenchus dipsaci* (Kühn) Filipjev, is a wonderment to researchers throughout the world. This species of nematode fascinates (and tends to frustrate) the scientists because it encompasses 20 or more distinct biological races that defy morphological separation. The races, which include teasel, red clover, white clover, alfalfa, rye, onion, potato, hyacinth, daffodil, and tulip, are distressingly individualistic. Some races parasitize and reproduce on a wide range of host plants. Other races have a nar-

row host range. Some races are unexpectedly not specific for related plant groups. For example, the red clover race parasitizes and reproduces on sunflower, celery, and pea, but not on alfalfa and white clover.

Alfalfa was first recognized as a host of *D. dipsaci* in 1881. Since then, the nematode has been carried with infested seed to every alfalfa-producing area of the world. It was first reported operating in the United States in 1923, and is found today wherever alfalfa is grown

Recent studies confirmed that crops grown in rotation with alfalfa in the western United States are susceptible to the alfalfa stem nematode

under irrigation in the western United States.

D. dipsaci inflicts severe losses on alfalfa — a loss that approaches two million dollars annually in Utah. Susceptible alfalfa stands can be destroyed in 2 to 4 years.

Greenhouse and laboratory studies recently confirmed that crops grown in rotation with alfalfa in the western United States such as (*Lycopersicon esculentum* Mill.), sugarbeet (*Beta vulgaris* L.), yellow sweetclover (*Melilotus indica* (L.) All.) bush bean (*Phaseolus vulgaris* L.), wheat (*Triticum durum* Desf.) and sainfoin (*Onobrychis viciaefolia* Scop.) vary in susceptibility to the alfalfa stem nematode when inoculated in the germinating seed stage (Table 1, 2).

The symptoms that were seen are characteristic of those noted by other researchers who have used the biological race specific for each plant being studied.

Onions prove the most susceptible of all cultivars studied, with all seedlings succumbing to parasitism after 28 days when grown at 15°-20°C. Infected onion seedlings

became stunted, abnormally white, twisted, and distorted with enlarged areas when infected with *D. dipsaci* (Figure 1). These symptoms resemble those observed when onions were infected with the onion or garlic race of nematodes.

Yellow sweetclover and sainfoin were stunted by alfalfa nematode infection, with symptoms similar to those induced in alfalfa. Typical cotyledonary node and hypocotyl swellings occurred, and some plants showed a marked necrosis (Figure 2a, 2b).

Tomato and sugarbeet plants were similar in their reactions to *D. dipsaci*. A malformation and bloating of the cotyledonary petioles were usually seen. The cotyledons became distorted and malformed, and primary leaves were distorted and swollen. There was a distinct swelling of the stem tissue, especially in tomato (Figure 3a, 3b, and 3c). Blindness (destruction of the apical meristematic tissue) was not uncommon and resulted in the death of the plant.

Wheat showed little or no distortion or galling following infection, and only a small percentage of the plants demonstrated a distinct ini-

tial stunting, which was partly overcome as plant age increased.

D. dipsaci infected the primary leaves of bush bean and caused a distortion and galling (Figure 4). Galled areas later became necrotic, the tissue collapsed, and the leaf had a shotgun appearance not unlike that caused by some of the necrotic lesion-inducing viruses.

Plant mortality differed among the cultivars tested and varied with different temperatures. Onion was the most susceptible while wheat and bean were the most tolerant and resistant (Table 2). All cultivars appeared to be more susceptible at the 15° C temperature which may be due to a greater nematode activity in relation to plant growth, to the plants suffering from a greater physiological shock due to infection by the nematode, or both.

The alfalfa stem nematode did not reproduce on onion, sweetclover, tomato, sugarbeet, or wheat (reproduction on bean has not been determined). It did, however, reproduce on sainfoin as readily as on alfalfa (Table 3). This constitutes the first indication or report of a Utah population reproducing on

Table 1. Effect of *Ditylenchus dipsaci* on growth of plant cultivars¹.

Cultivars	Plant ht (% of control)		Top weight (% of control)
	14 days	28 days	28 days
Alfalfa	32	20	7
Sainfoin	42	37	27
Onion	39	—	—
Sweetclover	41	50	30
Tomato	66	71	41
Sugarbeet	84	82	51
Wheat	73	92	57
Bean	83	96	75

Differences between inoculated and control plants were significant at 1% level in all cultivars, except for wheat and bean height after 28 days (wheat significant at 5% level; bean not significant).

¹Germinated seed inoculated with 20 *D. dipsaci*.

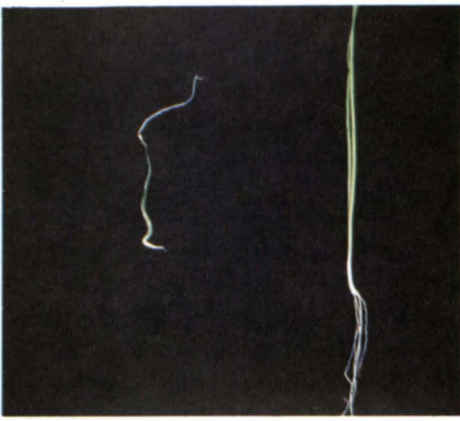


Figure 1.

20 C. Left: *Ditylenchus dipsaci* infected Sweet Spanish onion plant 32 days after inoculation. Note swollen and wrinkled coleoptile. Right: Control.



Figure 2a.

20 C. Left: Stunting and distortion of Yellow sweetclover by *Ditylenchus dipsaci* 32 days after inoculation. Symptoms are similar to those in alfalfa. Right: Control.



Figure 2b.

20 C. Left: Swollen and stunted Ranger alfalfa plant 32 days after inoculation with *Ditylenchus dipsaci*. Right: Control.



Figure 3a.

15 C. Left: Stone Improved tomato plants infected with *Ditylenchus dipsaci* 32 days after inoculation. Note stunting and distortion of primary leaves. Right: Control.



Figure 3b.

20 C. Left: Stone Improved tomato plant infected with *Dictylenchus dipsaci* 32 days after inoculation. Note distorted primary leaves and swollen hypocotyl. Right: Control.



Figure 3c.

15 C. Left: Pathogenicity of *Ditylenchus dipsaci* to sugarbeet 32 days after inoculation. Note stunting and distortion of primary leaves. Right: Control.

Table 2. Pathogenicity of *Ditylenchus dipsaci* to several plant cultivars¹.

Cultivars	Mortality (%) ²		
	15 C	20 C	25 C
Onion	100	100	40
Alfalfa	80	30	0
Sweetclover	70	10	0
Sainfoin	30	10	0
Tomato	20	30	0
Sugarbeet	20	20	0
Wheat	30	0	0
Bean	10	0	0

¹Plants inoculated with 50 *D. dipsaci* per seed.

²Readings made after 32 days' growth.

Table 3. Infection and population trends of *Ditylenchus dipsaci* in several plant cultivars¹

Cultivars	Plants infected (%) ²		Nematodes/infected plant ²	
	10 Days	28 Days	10 Days	28 Days
Alfalfa	100	100	26	68
Sainfoin	100	100	22	56
Onion ³	100	—	11	—
Sweetclover	90	65	12	10
Tomato	85	50	13	9
Sugarbeet	75	55	10	7
Wheat	65	30	7	4
Bean ⁴	50	30	—	—

¹Germinated seed inoculated with 20 *D. dipsaci* and grown at 20 C.

²Results taken from 20 plants per cultivar.

³100% mortality after 28 days.

⁴Reproduction not determined.

Onions are the most susceptible to the parasite

any plant other than alfalfa and could be significantly important if sainfoin is ever considered as a crop in nematode-infested areas.

Growers should be cognizant that under conditions ideal for the nematode, *D. dipsaci* may cause important plant losses within given cultivars if infection occurs soon after germination. Existing reports

of poor sugarbeet stands in fields that had been previously planted to alfalfa make our hypothesis meaningful and suggest that *D. dipsaci* could have been involved.

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Prescribed Burning — Effective Control of Sagebrush and Open Juniper

Michael Ralphs, David Schen, and Fee Busby

Millions of acres of western rangeland are dominated by stands of sagebrush and juniper. These brushlands are generally considered to be of low value for livestock forage, watershed protection, and wildlife habitat. Mechanical and chemical methods have been successfully used to manage these unproductive plants, but inflation has increased their cost and made them uneconomical in many situations.

Prescribed burning — the carefully planned use of fire — is an efficient and economical range management tool, however, and can be used to manage sagebrush and juniper. Fire is dangerous and can be destructive, but careful planning, application, and follow-up management can reduce the risk associated with prescribed burning.

Prescribed burning or any range improvement practice should be identified as necessary in a comprehensive, long-term ranch management plan. Assistance in developing a good plan can be obtained from the Soil Conservation Service, Bureau of Land Management, Forest Service, Utah Division of Wildlife Resources, Utah State Department of Forestry, and USU Extension Service. This paper discusses some of the precautions a manager must consider before selecting prescribed burning as a desirable range improvement practice.

Effect of Fire on Vegetation

All plants are affected by fire, but the extent of damage or benefit varies with the plant species and the intensity of the fire. The manager must know the plants he is working with and how they are affected by fire. The burning conditions and timing of the prescribed burn should be planned to benefit the desired plants in the community as well as damaging the target species.

The growing points of most grasses and some forbs are at the ground surface in the root crown. A fast moving, low intensity fire will consume the aerial vegetation without damaging the crown (note in Table 1 that some grasses such as Idaho fescue are severely damaged). However, the growing points of shrubs are at the tip of the branches and those without the ability to resprout from the root are killed by fire. Sagebrush and juniper do not resprout and are easily managed by prescribed burning. Rabbitbrush and other problem plants do resprout and cannot be managed this way.

Prescribed burning is an efficient and economical range management tool for sagebrush and juniper

Advantages of Prescribed Burning

- 1) Inexpensive control method. The major cash cost is for fuel breaks and ignition fuel and is usually less than \$.50/acre.

- 2) Releases soil moisture and nutrients for desirable vegetation.
- 3) Increases forage production for livestock and wildlife.
- 4) Increases palatability of vegetation on burned areas.
- 5) Temporarily increases winter yield.
- 6) Sagegrouse strutting grounds and key wildlife areas can be excluded from burn by fuel breaks.
- 7) Increases diversity of vegetation and improves wildlife habitat.

Disadvantages of Prescribed Burning

- 1) Risk of fire escaping and consuming valuable forage, causing property damage and danger to lives, resulting in expensive suppression costs and civil suits.

- 2) Soil erosion by wind and water until vegetative cover is re-established.
- 3) Increases the amount of cheatgrass if it is abundant in understory.
- 4) Rabbitbrush and other problem species that resprout from the root will increase after a fire and present additional management problems (Table 1).

The advantages and disadvantages should be evaluated for each project and where the disadvantages outweigh the advantages, alternative means of brush management should be chosen.

Late Summer and Fall Burning

Destructive wildfires often occur during July, August, and September when temperatures are high, humidity is low, and plant foliage is dry and flammable. However, if precautions are taken, these high

risk fire conditions can be used advantageously in prescribed burns. Adequate fuel breaks must be constructed and fire suppression equipment must be available to insure that the fire does not escape.

Broadcast burning of extensive areas — 200 hectares; (500 or more acres) — is best accomplished during late summer or fall. Large areas can be uniformly burned in a short time when the plants (fuel) are dry, relative humidity is less than 20 percent, daytime temperatures are above 24°C. (75°F), and steady winds from 16-24 km./hr. (10-15 mi./hr.) and from the desired direction occur.

Spring Burning

Early spring burning offers advantages for some special situations. Timing is critical because the prescribed burn must be conducted just after the snow melts and before sagebrush and juniper break dormancy. This often constitutes less than a two-week period. During this

Table 1. Foothill plants affected by fire.

Severely Damaged	Moderately Damaged	Slightly Damaged
Desirable¹	Desirable	Desirable
Bitterbrush	Bluebunch wheatgrass	Arrowleaf balsamroot
Cliffrose	Indian paintbrush	Crested wheatgrass
Curleaf mountainmahogany	Indian ricegrass	Douglas sedge
Eriogonum	Needle-and-thread	Sandberg bluegrass
Idaho fescue	Nevada bluegrass	Serviceberry
Threadleaf sedge	Penstemon	Snowberry
	Prairie Junegrass	True mountainmahogany
Undesirable¹	Squirreltail	Western wheatgrass
Sagebrush	Thurber needlegrass	Yarrow
Juniper		
Pinyon pine	Undesirable	Undesirable
Pussytoes	Tailcup lupine	Broom snakeweed
		Cheatgrass
		Deathcamas
		Horsebrush
		Rabbitbrush
		Velvet lupine

¹Desirable and undesirable classification is based on usability for livestock forage.

period, the foliage water content is low in relation to the volatile oils and the plants burn readily.

The temperatures during this season are low and the humidity is high. This results in a cool fire and only the dense concentrated sagebrush in the bottom of a draw will burn. Although the major targets of spring burns are small areas, the method can be a valuable tool in clearing out these potentially productive bottoms when fire suppression cost is minimal.

Planning

After the range manager has made the decision to use prescribed burning as a brush management tool, the Area Forester and District Fire Warden of the State Division of Forestry and Fire Control should be contacted for assistance in planning the individual burning project. These individuals can assist in recommending the season to burn, the size and number of burning units, the location and width of fuel breaks, desirable weather conditions, and the kind and amount of suppression equipment that will be needed during the fire. The Fire Warden will issue the burning permit when he is satisfied that proper precautions are included in the burning plan.

Fuel

Fuel type and density are probably the most important factors to consider in planning the number and size of burning units, the placement and width of fuel breaks, and the amount of suppression equipment needed. A fire will carry easily with only a light breeze in dense brush with moderate to heavy fine fuels (grass). Therefore, the area to be burned should be rested from grazing the season before the burn is planned. This allows a buildup of the needed fine fuels which is necessary for a safe and easily controlled fire. In sparse or moderately

dense brush with little fine fuel, a strong wind is necessary to carry a fire. The stronger or more gusty the wind, the greater the problems of fire control.

Topography

The general topography of the area surrounding the proposed burn as well as the topography of the site to be burned must be considered in determining the location and width of fuel breaks. The rate of fire spread will be much faster up a hill because of convection and radiant heat transfer which causes preheating of fuels ahead of the fire. Therefore, fuel breaks must be much wider if the fire is moving upslope.

Burning Units

Large prescribed burns — greater than 80 hectares (200 acres) — are often more safely conducted by dividing them into several small burns. The larger the area ignited at any one time, the greater the risk of problems occurring in fire control. The first units to be burned should be those on the downwind side of the area. Once these have been burned, since the wind will carry the fire in their direction, larger units may be safely burned.

Ignition of too large a tract and spreading control crews too thin around a large area are unnecessary safety risks.

Fuel Breaks

Although specific site conditions will dictate fuel break width and location, one can generally conclude that in moderate to dense juniper a break of 30.4 m. (100 feet) is required, while in sagebrush widths of 15.2 m. (50 feet) are generally adequate. These widths will have to be increased if the planned fire direction is upslope or sparse fuel necessitates burning in strong winds.

The entire fuel break may be constructed with dozers, although this may prove more costly than necessary and certainly causes some undesirable scarring of the area. Another way is to cut a narrow break with the dozer and then burn strips parallel to the dozed break. These strips can be burned when fire conditions are conducive to safer burning (during the late afternoon). Several strips may need to be burned to obtain the desired total width.

A new device being developed by the Forest Service may eliminate the need for dozing any fuel breaks. It consists of a propane burning unit mounted on a trailer with large blower fans. The unit can light a fire in wet or moist conditions, the blowers fanning the fire until the plants ignited by the burners are killed. Several of these strips may be burned to achieve the desired total width. In wet or moist conditions, however, (in spring, after plants have broken dormancy) the fire will not spread.

If possible, existing roads should be used for fuel breaks; new breaks may serve as roads.

Application

On the day of the burn, the Fire Warden, Area Forester, or whoever is designated as the Fire Boss should direct all activities. Strong leadership is very important in conducting a safe and organized burn.

Fire Weather

Weather factors such as relative humidity, wind velocity, wind direction, and temperature have a direct influence upon the likelihood of conducting a safe and efficient burn. The prevailing midday wind direction should have been determined in the planning process and considered in setting up the burn-

ing units. The humidity, temperature, and wind velocity and direction for the day of the burn is essential information and can be obtained from an on-site mobile weather station provided by the US Weather Service. For best results, the day of the burn should have a predicted humidity less than 20 percent, temperature above 24°C (75°F), and a steady wind 13 to 24 km./hr. (8 to 15 mi./hr.).

Ignition

The burning units on the downwind should be ignited first. They can be backfired if there is little wind and adequate fuel to carry the fire. Ignition can be done with either backpack or mobile burners. It is important to ignite the entire width of the unit as rapidly as possible to create a line of fire that the wind can carry uniformly over the unit. If the burn is patchy, it may be necessary to treat individually the unburned islands.

Suppression

In the planning process, it is necessary to arrange for fire suppression equipment and fire crews to be on the site both in burning out the fire guards and for the actual broadcast burn. The amount of suppression equipment and size of crews will be determined by the Fire Warden or Fire Boss based on the size of the burn, topography, and burning condition. Equipment and manpower must be strategically located to immediately suppress any fire that escapes the fuel breaks.

Follow-Up Management

Follow-up management is the most important aspect of a controlled burn and must be provided for in the overall management plan. On areas lacking sufficient desirable grasses in the understory (less than 20 percent of vegetative cover), re-seeding may be necessary to insure

a rapid recovery of the site. Resting the unit for two growing seasons provides for the establishment of seeded grasses and the increased vigor and density of the native grasses. Proper grazing thereafter with periodic rest will extend the increased forage production for many years.

Sagebrush and juniper and other undesirable shrubs are natural components of the ecosystem and will become re-established on the burned area. If these again become dominant, it may be necessary to retreat the site in order to maintain a productive condition.

An Example — The Park Valley Demonstration Ranch*

One pasture in the Park Valley Hereford Corporation Ranch, north of Park Valley, Utah, was successfully burned during September, 1974. The general procedures followed are discussed to illustrate how proper planning makes prescribed burning a useful management tool.

Figure 1 illustrates the existing characteristics of the project area. The area selected to burn was flat to gently sloping. Similar topography occurred on adjacent lands on the east, west, and south. Steep mountain slopes with sparse vegetation are adjacent to the area on the north.

Soils were generally shallow and rocky. However, a good grass stand resulted from reseeded a wildfire that occurred in 1970. This seeding served as an indication of what could be expected from prescribed burning and seeding on these soils.

Roads existed prior to the burn and were utilized as fuel breaks and unit dividers. Additional breaks were constructed with a D-8 Caterpillar dozer. These breaks were 10-15 feet wide. The width was increased to approximately 50 to 100

feet by burning strips on the downwind side of the units.

The juniper stand was dense and the sagebrush stand was sparse to dense. The area had been grazed prior to the burn and very little fine fuel was available to help carry the fire. Vegetation in the draws was very dense.

Units 1, 2, and 4 in Figure 2 were burned first to provide additional breaks near the steep mountain slopes. This allowed the larger Units 3, 5, and 6 to be more safely burned. A US Weather Bureau mobile unit was used to monitor fire weather conditions prior to the burn.

The juniper burned poorly in the morning but burned well in the afternoon (noon to 4:00 pm) after temperatures increased, relative humidity decreased, and a steady, moderate 16 to 24 km./hr. (10 to 15 mi./hr.) wind prevailed. Juniper burned well only where conditions allowed crown fires to develop.

The sagebrush burned well from 10:00 am to 4:00 pm except for sparsely vegetated areas. Winds from 8 to 16 km./hr. (5 to 10 mi./hr.) were required to carry the fire through most areas of sagebrush.

The dense vegetation in the draws burned readily throughout the day. These possibly could have been burned in the spring and then utilized as fuel breaks during the fall prescribed burn.

It became more difficult to burn during the late afternoon. As temperatures decrease, relative humidity increases and plants burn much slower. Therefore, late afternoon would be a safe time to burn fuel breaks or dense stands of easily burned vegetation.

Control efforts were minimal with suppression required once in

*Demonstration Ranch Program is conducted with the assistance of the Four Corners Regional Commission.

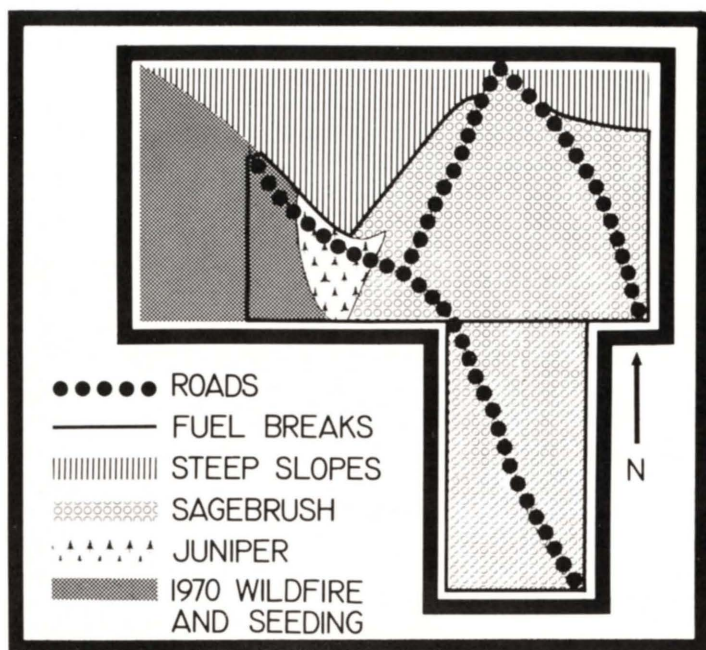


Figure 1. Characteristics of Park Valley prescribed burn area.

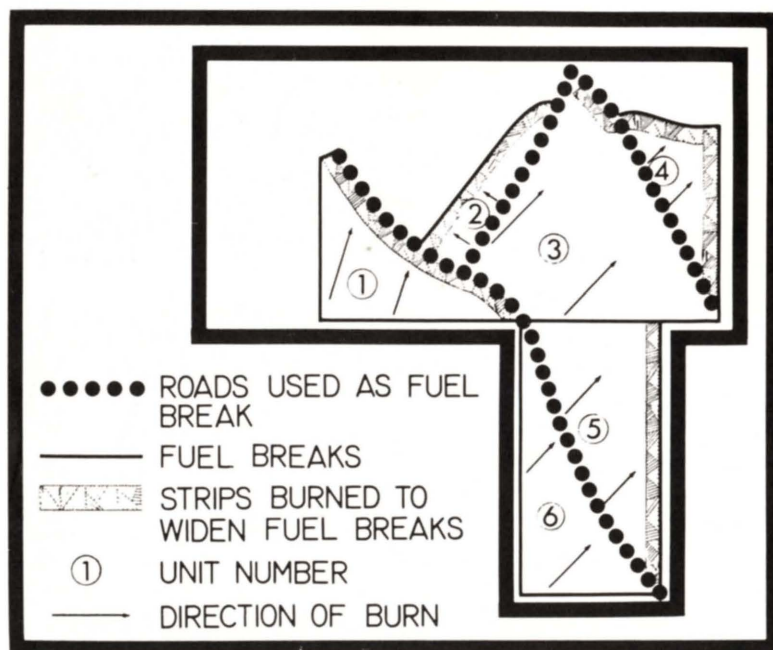


Figure 2. Sequence of burning units.

Unit 2 and twice in Unit 3. In both cases steep slopes adjoined the area resulting in fuel preheating and ignition by convection or fire brands. The problem could have been lessened by wider or relocated fuel breaks. Whirlwinds were a continual threat but caused no problems.

Control equipment on hand included two 1,000 gallon tankers, four 250 gallon 4 X 4 pumper units, and a SCD D-8 Cat. There were 20 men on the scene, adequate for the job.

The prescribed burn was a total success. The actual cash cost of the burn was \$.99 per hectare (\$.40 per acre). This included fire line construction and fuel for the ignition torches. If the volunteer labor and equipment was included, the total cost of the burn would have been \$7.81 per hectare (\$3.16 per acre). The costs are considerably less than \$17.30 per hectare (\$7.00 per acre) for spraying sagebrush and \$44.48 per hectare (\$18.00 per acre) for chaining juniper. The area was drilled to crested wheatgrass in November and is growing successfully.

Summary

In considering prescribed burning as a range improvement tool, three major considerations stand out. 1) The prescribed burn should be one of several alternatives of improvements considered in an overall ranch improvement and management plan. 2) Careful planning for the prescribed burn is required in order to obtain the desired results and minimize the risks associated with fire. 3) Follow-up management is essential in establishing a productive forage cover and extending its useful lifetime.

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Know Your Sagebrush — And Better Your Range

W. T. McDonough and R. O. Harniss

Varieties of both crop and wild plant species may vary widely in growth habits, hardiness, and yield, as well as in flavor and nutritive value of edible parts. In evaluating varieties of range plants, we therefore look at readiness of establishment, yield or productivity, and palatability, since these characteristics determine the plant's potential for erosion control, cover for animals, and forage for grazing animals.

Big sagebrush (*Artemisia tridentata*), the dominant shrub in the cool desert region of the Great Basin, has three subspecies that differ in habitat occupied, in palatability, and in morphological characters (McArthur et al. 1974). Photographs of representative plants of the three subspecies are shown in Figure 1. Basin big sagebrush (subsp. *tridentata*) occupies the deeper soils of valleys and foothills and is an aggressive invader of rangelands depleted by overgrazing or fire. Wyoming big sagebrush (subsp. *wyomingensis*) occupies

hot, dry sites in the valleys and foothills. Mountain big sagebrush (subsp. *vaseyana*) occupies colder and wetter sites at relatively high elevations.

Much of the effort to eradicate big sagebrush has been expended without regard to the subspecies involved. However, workers are beginning to recognize that, with selective breeding programs and adequate field control of density, these well-adapted shrubs can fill an important place in native plant communities (Plummer et al. 1968, McArthur et al. 1974).

It seemed reasonable to expect the three subspecies of big sagebrush to differ in readiness of establishment, aggressiveness in invading rangelands, and in resistance to eradication or control measures. Therefore, we investigated germination and seedling growth in the subspecies in relation to critical environmental conditions — temperature and simulated drought.

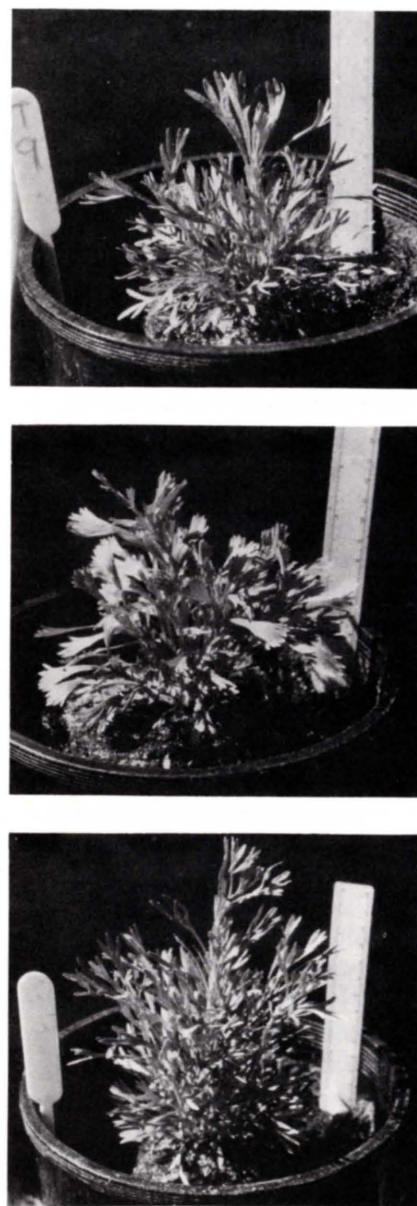


Figure 1.
Representative plants of the three subspecies of big sagebrush, subsp. *tridentata* (top), subsp. *vaseyana* (center), and subsp. *wyomingensis* (bottom).

Photos by W. T. McDonough

How Tests Were Run

In 1971, 1972, and 1973, individual seed collections were made from 10 plants of each of the three subspecies in the vicinity of Dubois, Idaho. Germination tests were run either under conditions of ample water or of simulated drought; mannitol solutions were used that restrict the availability of water to the seeds. Seed incubation temperatures included three constant and six alternating (day-night) temperatures between 2° and 30°C, plus a constant stratification or simulated overwintering temperature of 2°C. Seeds were examined daily to determine both rate or speed of germination and total germination after 30 days.

Resultant seedlings were kept in growth chambers for 12 weeks at alternating temperatures that simulated below average, average, and above average late-spring through early-summer temperature conditions in the collection area, determined from 40 years of weekly weather records obtained from the University of Idaho. Plants were then harvested for determinations of oven-dry weights of shoots.

Germination and Seedling Growth Results

Results of the germination tests are illustrated in relation to temperature (Figure 2), overwintering treatment (Figure 3), and simulated drought (Figure 4).

Total germination after 30 days was highly variable and did not differ significantly (1 percent level) with temperature within the subspecies (Figure 2). Subsp. *vaseyana*, however, had lower germination percentages than the other subspecies throughout the temperature range. Speed of germination, expressed as the number of days required to reach one-half of the 30-day percentage, ranged from 2 to 18 days, depending upon the incu-

bation temperature and the subspecies. Subsp. *tridentata* germinated fastest and subsp. *vaseyana* slowest. Variations in year-to-year germination over a 3-year period was high, but differences were statistically significant only in subsp. *tridentata*.

The simulated overwintering treatment significantly increased total germination only in subsp. *vaseyana* (Figure 3). The chief effect of overwintering was to greatly increase the speed of germination in all subspecies — to 1 to 2 days after transfer of the seeds to a higher temperature (20°C day/10°C night).

Germination of seeds not given a 50-day overwintering treatment decreased rapidly with increasing water stress. This decline was particularly evident in subsp. *vaseyana* (Figure 4). Following an overwintering treatment, germination was much less affected by water stress, even under the maximum stress tested (Figure 4).

Results of the seedling growth tests are shown in Figure 5. Survival and growth of seedlings were good under the three temperature regimens tested, although significantly less under the below average conditions for each subspecies. As with seed germination, growth variation among individuals within subspecies was high and probably represents individual genetic variability from extensive cross-pollination.

What Was Learned about Each Subspecies

Although the subspecies differed in germination and seedling growth, these variations were not large enough to imply different responses to management. The climates of the habitats occupied generally provide the overwintering necessary for optimum germination and spring conditions that favor high seedling emergence, survival, and vigorous growth.

With selective breeding programs and adequate field control of density, these well-adapted shrubs can fill an important place in native plant communities.

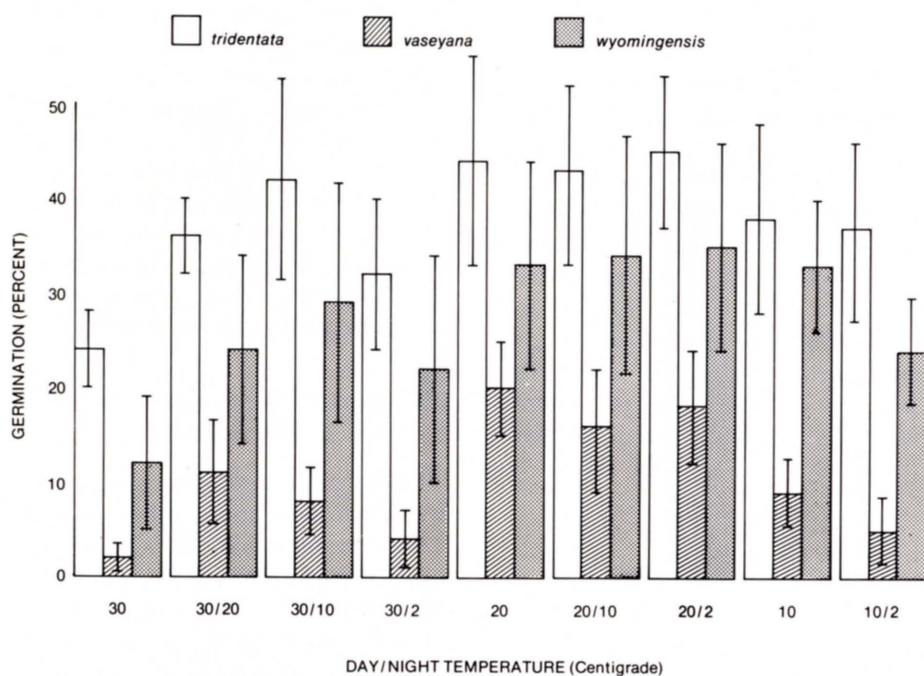


Figure 2.
Effect of temperature on mean germination \pm standard deviation (vertical lines) of big sagebrush subspecies.

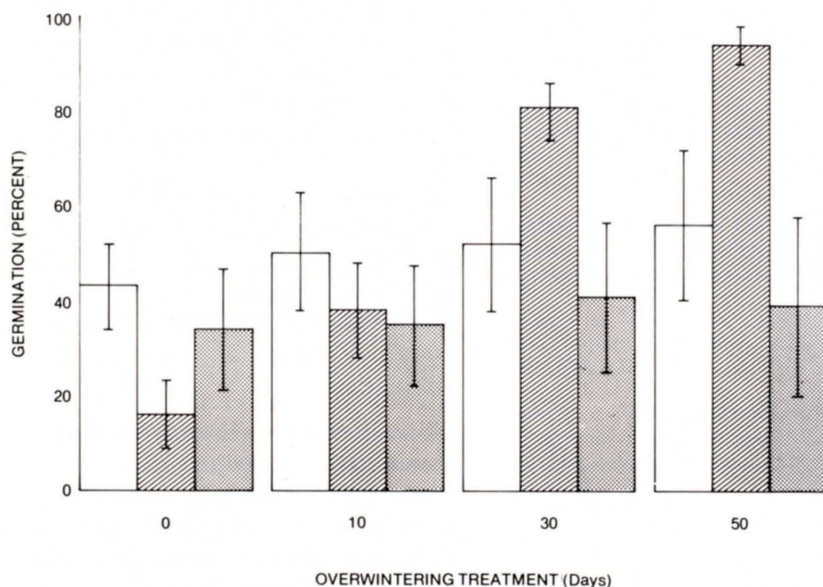


Figure 3.
Effect of 10- to 50-day stratification of overwintering treatment and no such treatment (0 days) on subsequent germination of big sagebrush subspecies.

None of the subspecies require a particular temperature for germination over a wide range that simulated spring-through-fall conditions in the areas occupied. Limited germination could therefore take place in any of these seasons if soil water levels were high for the time required for germination to begin. Without the overwintering treatment, seeds proved to be sensitive to even moderate water stress. Except for that following natural overwintering, water stress is probably the limiting factor for germination. In early spring, snowmelt, lower temperatures, and higher seasonal precipitation are likely to maintain high soil water levels for relatively long periods. For all subspecies, overwintering would promote prompt germination and an advance crop of well-established seedlings before the start of any summer drought. Thus, the early-to-midspring period favors maintenance and extension of the ranges of all the subspecies by seed reproduction.

A high proportion of seeds in the individual collections were non-germinating and pronounced plant-to-plant and year-to-year variation occurred. However, the population of mature plants of each subspecies in favorable areas is always sufficiently large and the 30- to 50-year life span of adult plants (Young and Evans 1974) sufficiently long to insure an adequate supply of germinable seeds every fall. Therefore, an undisturbed, or even moderately disturbed, population probably does not experience good or poor years for seed production. It seems likely that plenty of seeds for high establishment are produced every fall and that a high percentage of them are ready to germinate the following spring.

Seedling growth was relatively insensitive to air temperatures over a range that simulated below-to-above average conditions in spring

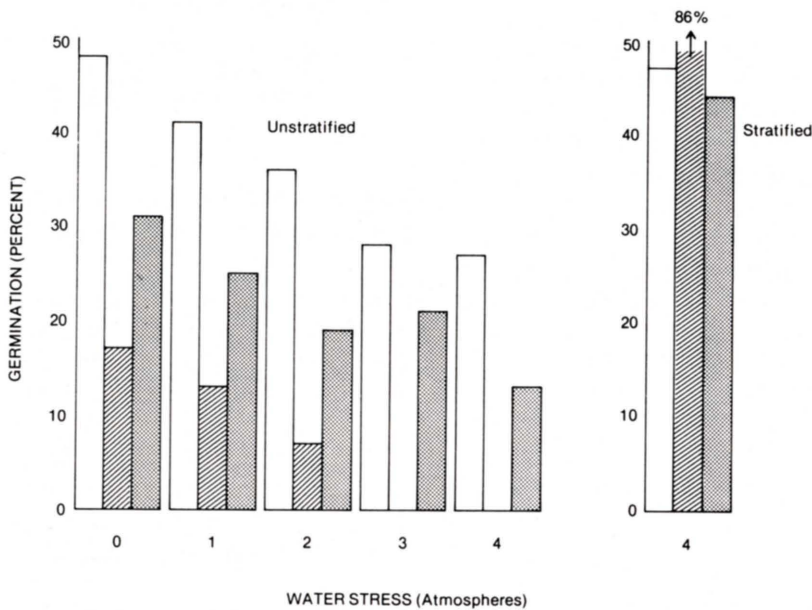


Figure 4.
Effect of increasing water stress on germination of stratified and unstratified seeds of big sagebrush subspecies.

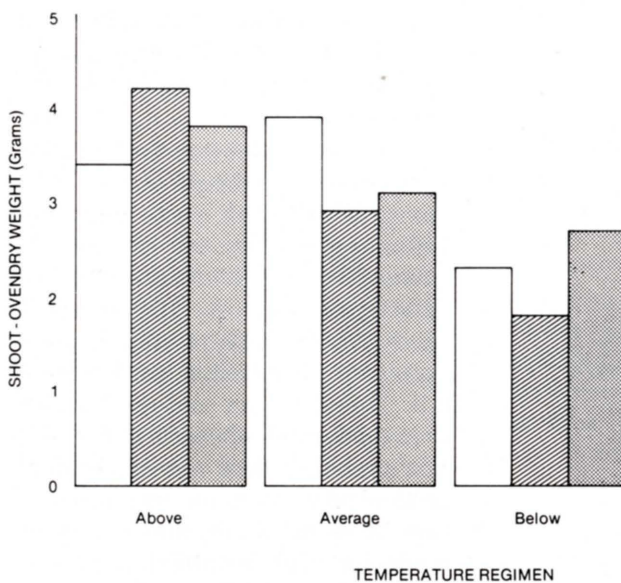


Figure 5.
Effect of simulated temperature regimens on seedling growth of big sagebrush subspecies.

through early summer in southern Idaho and northern Utah. Although growth in all subspecies was depressed under below average temperatures, the amount of growth seemed to be adequate for a high rate of establishment in areas subject to invasion, unless low temperatures were combined with other adverse conditions, such as exceptional drought or severe competition.

When And Where Is Control Needed?

Large scale eradication of sagebrush would be undesirable, even if it were practicable. All subspecies provide good cover and soil stability (McArthur et al. 1974); but they differ sufficiently in palatability and other characteristics to prevent treating them as an entity.

Subspecies *vaseyana* has medium palatability (McArthur et al. 1974) and undoubtedly has a place in the upland communities from both an economic and ecological point of view. This subspecies, however, vigorously invades good rangelands in thick stands, suggesting that selective eradication should be planned on a continuing basis (Harniss and Murray 1973).

Subspecies *wyomingensis* is highly palatable and is adapted to drier sites in the valleys and foothills. Sites supporting this subspecies should probably be closely examined before any controls are initiated.

Subspecies *tridentata* once dominated the deeper valley soils presently used for crop production. It is now largely confined to peripheral areas and harsher sites unsuited to crops or forage. With its low palatability and aggressive nature, it can be a problem on the better sites at higher elevations and probably requires stricter control.

Seed reproduction probably functions importantly in the spread of

each subspecies into adjacent areas. Wind dispersal of seeds is moderately effective; Daubenmire (1975) found seedlings of subsp. *tridentata* as far as 33 m from the nearest possible source plant. Since the seeds have no effective morphological mechanism for more distant dispersal, the range probably is slowly extended through contiguous bands around the periphery of established stands. Once the critical early stages of germination and seedling growth are successfully accomplished persistence is assured by the high adaptiveness of each subspecies to its environment.

Where any subspecies is spreading into adjacent plant communities, seedlings probably can be easily eliminated in the spring with selective herbicides over the restricted area subject to colonization. Summer and fall conditions for germination of sagebrush usually are unfavorable. Year-to-year carry-over of viable seeds probably is low, since laboratory tests showed that retention of germinability of seeds after 3 years refrigerated storage was reduced 70 to 80 percent compared to the freshly collected seeds of the same lots. Control of emergent seedlings of sagebrush therefore is easier than with species such as aggressive annuals, that show intermittent germination and high carryover of viable seeds from year to year. With such species, eradication efforts must be repeated throughout every growing season (Kay and Owens 1970). The rapid and essentially simultaneous germination of sagebrush seeds that follows overwintering and the generally restricted areas of invasion should make such selective eradication relatively easy, in contrast to attempts to eradicate plants in established stands. Unless a vigorous understory of perennials is present, an attack on established stands only promotes abundant seed regeneration by the sagebrush and annuals by removing competi-

tion (Young and Evans 1974).

Although not determined, the seedling stage of sagebrush is probably sensitive to low concentrations of herbicides that would cause minimal damage to mature plants of other species. Because of their rapid growth, relatively small shoot and root volumes, and lack of thick cuticular layers and woody tissues, sagebrush seedlings could be treated for eradication as are emergent annuals (Young, Evans, and Eckert 1969).

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SCIENCE SHORT

MORE WATER MEANS MORE MANAGEMENT OPTIONS

In at least some cases, Bureau of Reclamation projects produce benefits at the farm family level beyond the normally cited increases in crop yields and/or increased farm income from improved yields. Reed Willis, postdoctoral economist working at USU in 1973-74, identified some such project benefits.

Based on an investigation of 6 Bureau of Reclamation projects (Emery and Vernal in Utah, Florida and Silt in Colorado, Mann Creek and Minidoka in Idaho), Dr. Willis decided that he would consider four categories of management options that develop when supplemental water becomes available. The first included changes in cropping patterns, in crops grown, and in crop yields. The second involved basic changes in land use such as conversion to housing, recreation, industry, or roads. The third category hinged upon the proximity of possibilities for part-or full-time off-farm employment. The fourth included the introduction of new crop and/or machine technology. Decisions by a family within any one or all of these categories would, of course, have a potential impact on that family's overall well-being.

Questions

The questions Dr. Willis wanted to answer were: Did being given access to such options generally mean improved family well-being? And, if so, could the opening up of new management options be legitimately considered a water-project-

induced benefit? If it could, evaluations of Bureau of Reclamation projects should give some attention to their option-producing abilities.

Willis's six projects actually encompassed *three* quite different situations. His analysis showed that farmers in both the Emery and Vernal projects were greatly influenced by the ready availability of off-farm employment opportunities and by the then-prevailing good prices commanded by beef animals. With the extra water supplied by the project, these farmers tended to shift their cropping patterns toward crops requiring less intensive management practices but more water — such as pasture. By exercising that management option, the farmers were able to maintain their agricultural enterprises while simultaneously gaining more income through off-farm employment.

The Florida, Silt, and Mann Creek

projects were all located in mountainous country and mostly supported livestock enterprises. As these farmers gained access to project-supplied water, they often chose to yield to external pressures to let some their land be used for subdivisions and recreation, while simultaneously shifting toward crops that needed more water but less management than they'd applied in the pre-project times. Very few farmers in these projects (except Florida) have had access to off-farm employment opportunities.

In complete contrast to the other five projects, the Minidoka unit involved the "opening" of previously uncultivated land to farming enterprises. The people who moved on to these acreages have tended to use the project water to support an intensive, irrigation-based cropping pattern. Few are engaged in off-farm employment, and there is no pressure to shift the land into subdivi-

sions or recreation developments.

While the six projects differ among themselves because of their specific locations and surrounding economies, the land values in each increased after project water became available. Willis concluded that these upward shifts in land values were due in each case to one or more of three possibilities. These possibilities (capitalizing the value of water into land prices, selling water rights and realizing capital gains, and capitalizing values of external recreational and industrial development values into the land value) all represented additional management options that had been made available to farmers in the project units by the project itself. While it is impossible to generalize from this limited study to *all* Bureau of Reclamation projects — much less to *all* public investments — Willis's research does point toward ways to improve the accuracy of cost/benefit analyses of public investment.

The Colorado River and Agriculture/Energy Equations

John Keith, Jay Anderson, and B. Delworth Gardner

Must it be an agriculture-versus-energy decision in the Colorado River Basin? Unfortunately, that's the way it looks.

Research results from USU and elsewhere indicated that all of the projected large-scale energy developments will affect the quantity and quality of water in the Basin. That is a truism, whether the energy production emphasizes one or all of

three alternatives: oil shale and other petroleum development; coal mining, liquefaction, and gasification; and fossil fuel and nuclear-fired electrical power generation.

Why a Problem?

By 1985, if current development plans are realized, energy production in the Colorado River Basin will require a lot of water (Table 1).

Table 1. Consumptive use of water for energy (from unpublished data by J. C. Batty).

	Annual Use 1,000 Acre ft/yr
Coal Gasification	200-900
Coal Liquefaction	100-650
Coal Fired Electrical Gen.	300-400
Oil Shale	100-200
Coal Pipelines	30-60
Coal Mining	14-23
Nuclear Power	10-20
Oil Refining	6-12
Total	700-2300

The total indicated in the table can be contrasted with the 5,600,000 acre feet of water diverted by agriculture in 1970. Right now, users in the lower Colorado Basin are benefitting from unallocated Upper Basin water. Pending applications for water rights in the Upper Basin, however, far exceed the available water.

Quantities

The picture becomes more complicated when we realize that a consumptive use of 700,000 acre feet would actually require a diversion of over a million acre feet. Approximately 1,500,000 acre feet would have to be diverted just to satisfy the cooling needs of energy production in 1985. In general, energy consumptive use devours between 30 and 40 percent of its diversions. By contrast, total agricultural consumptive use in the Basin is averaging 50 to 60 percent of all diversions.

The water shifted to energy would inevitably lower the quantity available to agriculture. Even if the water returned to the Colorado by energy enterprises is reallocated, 75,000 to 200,000 acres are likely to be forced out of agricultural production because of lack of water.

Changes in quantities of available water would obviously be only one part of the problem. Water quality considerations are another contributor.

Quality

The Colorado River naturally carries substantial loads of salts and sediments. Consumptive uses can concentrate these salt and sediment contents in the waters that they return to the river.

Even under optimal conditions and management, gravity-flow irrigation results in a salinity buildup

in its runoff waters. Similarly, energy development enterprises can concentrate and/or add varying amounts of salts and other pollutants to the waters they return to the river, although probably in amounts significantly less than those from agriculture.

Agriculture's greater consumptive rate implies a greater tendency to concentrate pollutants downstream for a given diversion. Evaluations of the comparative loading and concentrating effects, however, must await extensive data gathering analyses. Without reliable data as a basis for computer modeling of alternatives, a costly trial and error period seems unavoidable.

Management Options

All of the above, obviously, is based on the assumption that energy enterprises will return non-consumed waters to the river. In reality, the present policy trends point towards having the projected energy developments return none of their allocated water. If this trend is sustained, it would mean an annual removal of at least 700,000 acre feet from the river. Such removal, with no return flows, could increase pollutant concentrations downstream compared to once-through cooling. Both processes consumptively use 700,000 acre feet but once-through requires more total water flow and thus probably reduces loading from agriculture.

Existing and proposed water laws appear inadequate to the situation since they condone inefficiency and inequitable distribution of costs and benefits. Laws that have traditionally governed water allocation disputes often hamper efforts to improve quality. Then too, unequivocal identification of diffuse pollution sources and their quantities can be impracticably difficult to achieve.

Even so, development is occurring and management options are being debated. These debates, however, are unlikely to produce viable results and long-term social benefits unless public and private agencies act with unprecedented speed to mount significant research efforts. Prudence demands predefinition of future energy developments and their potential effects on the quantity and quality of Basin water. Lack of such foresight could cause inefficiency and inequity in water allocation and thus jeopardize the future welfare of the Basin and its people.

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Zinc Deficiency in Utah Field Corn — Its Diagnosis and Treatment

D. W. James and P. D. Christensen

Zinc deficiency in corn can be readily recognized because of the distinctive symptoms in the plant. Zinc deficiency occurs as an interveinal chlorosis in leaves. In mild cases, the lower or older leaves will appear striped. In severe cases, the chlorotic strips broaden until they coalesce so that the veins lose their pigment. The affected area, no longer striped, appears pale yellow or white and somewhat translucent. In Central Utah it was observed that the chlorotic tissue had a tendency to change from pale yellow or white to pale red. Lower or older leaves may die. (Figures 1 and 2).

Zinc deficiency symptoms may occur in very young plants from the seedling stage to about ten inches high. In plants that are further along, the older leaves show the symptoms and the younger leaves look normal. In moderate to severe deficiency, the plants will be stunted. It has been observed in other states that corn may completely outgrow or overcome a mild zinc deficiency. In these cases there may be no effect on crop performance except to delay maturity a few days. With severe zinc deficiency, crop yield will be restricted or eliminated.

Foliar zinc deficiency symptoms rarely occur uniformly in a field. They usually appear in a spotty pattern as indicated in Figure 3. For this reason evaluation of zinc nutritional problems by plant tissue sampling and soil sampling is sometimes difficult because of field variability. It is therefore desirable

to identify the portions of a field that are low in zinc and those that are normal, then, sample the field accordingly.

Why Zinc?

Zinc is classified among the minor or micronutrient elements because the amount required for normal plant nutrition is small compared with nitrogen and other major nutrients. For example, a 25-ton crop of corn will contain more than 150 pounds of nitrogen but less than one pound of zinc. Extensive in the United States, zinc deficiency has been identified in a wide variety of crops. As far as minor element fertilization is concerned, zinc is probably more important than any other micronutrient.

In Utah, zinc deficiencies in tree fruits, including apples, peaches, cherries, and apricots, have been known for more than 25 years. Several types of recommended practices have been available to fruit growers for diagnosing and eliminating zinc deficiency in fruit crops.

Zinc deficiency in Utah field crops was suspected in various fields in the 1960s but not positively identified until 1972, when zinc deficient corn was found in Central Utah.

Diagnosis by Tissue Analysis

Plant tissue analysis can be used to verify zinc deficiency, providing the pattern of zinc variations in the

With severe zinc deficiency, crop yield will be restricted or eliminated

leaves are recognized and accounted for in the leaf sampling procedures. Diagnosis of zinc deficiency by foliar analysis is complicated, because the concentration of leaf-zinc changes a) from older to younger leaves, and b) during the growing season.

Healthy corn leaf tissue ranges in zinc (dry weight basis) from 20 to 80 ppm (parts per million). On the other hand, zinc-deficient plants usually contain less than 15 ppm. Some may be as low as 7 ppm. During the growing season, zinc concentrations tend to increase. Thus it is possible to find 20 or more ppm of zinc in the upper leaves of a corn plant which has zinc deficiency symptoms in the lower leaves.

The variations in leaf zinc may be minimized by using the following leaf sampling technique: In the early part of the season — from the seedling to the beginning of the ear node stage — sample the youngest fully expanded leaf (the flag leaf). After the ear node can be identified, sample the leaf opposite to and below the ear node.

A leaf sample should consist of 10-15 leaves from that many different plants selected from field areas that are alike in crop symptoms. Collect one sample from areas suspected of being zinc deficient. Take a separate sample from field areas appearing normal. The leaf samples may be air dried before sending them to the laboratory. In the laboratory before the nutrient determinations are made, the sample will be oven-dried.

Diagnosis by Soil Testing

Zinc availability in soil can be evaluated by laboratory soil tests. A satisfactory testing procedure has been developed at Colorado State University in which the soil sample is extracted with DTPA. DTPA is an

organic chelating agent that complexes and solubilizes zinc and other metals including iron and manganese.

The zinc soil test is interpreted as follows:

Soil Test Zinc	Relative Zinc Availability
Less than 0.4 ppm	Low: corn will be deficient
0.4 to 0.6 ppm	Marginal
Greater than 0.6 ppm	Adequate

The soil test for zinc may reach as high as 2 ppm in productive soils. This, of course, reflects an abundance of zinc for plant nutrition.

Zinc Fertilization

Zinc can be applied to the leaves of plants; except in specific situations, however, soil treatments are preferred.

Zinc is immobile in soil and, as indicated above, is present in very small quantities. Furthermore, its application rates are very low compared to other fertilizer elements. Two or three pounds per acre of zinc, in any of several fertilizer forms, may be adequate. Frequently, 11.2 kg of the element per hectare (10 lbs/acre) will be recommended as a treatment to last for several years.

Zinc fertilizers for corn and other annual crops are most effective if applied broadcast and plowed under. Surface applications without soil incorporation may give no benefit. Zinc banded or sidedressed has only limited utility. In other words, zinc fertilizer should be dispersed as thoroughly as possible throughout the plow layer.

Foliar applications of soluble zinc compounds can effectively eliminate zinc deficiencies in corn.

Except in specific situations, soil treatments are preferred



Foliar applications are not recommended routinely, except in stop-gap situations to treat deficiencies that were not otherwise anticipated. For fruit trees, foliar zinc treatment is the principal recommended practice, because deep soil incorporation into the tree root zone is impractical. With corn and other field crops, however, soil testing can signal a need for zinc. Fertilization can be done in advance of planting, and loss of yield will be avoided.

Forms and Rates

Many kinds of zinc compounds are very effective as fertilizers. Commercially available materials include highly soluble, completely insoluble and complexed or chelated materials.

Because of the small amount of material required, uniform spreading can be a major problem in applying zinc. For example, only 28 pounds of zinc sulfate (36 percent Zn) are needed for a 10-pound application of zinc. To uniformly apply this in dry form is very difficult. Two methods can be employed to enhance uniformity of application: 1) The zinc materials can be blended or mixed and applied

with dry or slurry-type fertilizers. This usually requires special procedures and equipment. 2) Soluble zinc compounds can be dissolved in water and sprayed on the soil, or applied in solution with nitrogen fertilizers and compatible pesticides.

Zinc sulfate is frequently used. It is readily soluble in water. It can be mixed with nitrogen fertilizers, or it can be sprayed directly on the soil.

Some zinc fertilizers are a by-product of the mining and smelting industry. A very economical fertilizer form from this source is a solid material (insoluble) containing a mixture of zinc, manganese, and ammonium sulfate. This material blends very readily with solid fertilizers such as treble superphosphate (0-45-0) and ammonium phosphate (16-48-0).

Other important commercially available fertilizers include a variety of organic preparations or chelates. These are very effective sources of zinc for plants. The use of these forms may reduce the total amount of the element needed to overcome the deficiency. For example, if 5 or



Photo by L. C. Boawn, USDA, ARS

Figure 1.

Zinc deficient corn plant showing interveinal chlorosis. Older leaves have taken on reddish cast.



Photo by L. C. Boawn, USDA, ARS

Figure 2.

Corn leaves showing varying degrees of zinc deficiency. Bottom leaf is normal.



Photo by David James

Figure 3.

Spotty pattern of foliar zinc deficiency in a field of corn.

10 pounds of the element as zinc sulfate is needed, probably 2 or 3 pounds of the element in the chelate form will suffice. The organic preparations are usually more expensive, however. The final decision on the form of zinc to be applied should be based on the cost per unit of the element, convenience, (i.e., solid or solution, mixed with other materials, or straight) and timing.

Where deficiency symptoms or soil tests signal the need for zinc,

apply 5.6-11.2 kg pounds of the element per hectare (5-10 lbs/acre), and monitor the soil in subsequent years by soil testing to determine when a re-application is needed.

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Do Tillage Practices Affect Wheat Yields?

Rex F. Nielson and G. A. Van Epps

It is generally agreed that the function of tillage in dryland wheat production is to control weeds, develop a seedbed, incorporate crop residues, reduce erosion, and manipulate soil moisture by influencing water intake and evaporation.

Tillage practices on the drylands of Utah have seen major changes in the past fifty years, evolving from the simple horsedrawn equipment of the past to the large power units of today with their broad array of equipment. These changes have come about largely to increase efficiency and to reduce labor costs. The consolidation of small farms into larger units has made necessary

the continued change to larger and more sophisticated equipment. This mechanical revolution has not materially affected the reason why farmers till the land but only how fast and economically the job can be accomplished.

Research on tillage was conducted for many years in Utah at the Nephi Dryland Station with the results being published in 1954 in Experiment Station Bulletin 371. These data suggest that plowing to a depth of 12.7 to 20 cm (5 to 8 in) was the most effective, and that subsoiling did not increase yields. There was no difference in yields between spring and fall plowing when

Photos by Rex Neilson

Discing in the fall is a standard practice with many Utah dry farmers.

spring plowing was done as early as possible, although delay in spring plowing reduced wheat yields. Cultivation of fallow more than was necessary to control weeds did not increase yields, either.

Investigations carried out at Nephi since 1954 have involved different tillage treatments to measure the effect of partial to complete incorporation of the stubble. Results showed that complete incorporation of the stubble (moldboard plow) generally produced the largest yields and the highest protein. No yield differences were measured among the various tillage practices that left straw residues on the surface. Instead, plowing under the straw had a marked beneficial effect on the nitrogen-supplying power of the soil. The soils, climate, and farming practices in the Nephi area, however, are markedly different from those in northern Utah and tillage practices effective in Nephi are not necessarily applicable to conditions in Box Elder and Cache counties.

Bluecreek Farm

When the new dryland station was established in Box Elder County at Bluecreek, one of the first requests by growers there was to evaluate the different tillage practices being used by farmers in the area. After interviewing many growers it was determined that the choice of tillage programs was influenced by many factors. Crop residues, soil erodibility, weed growth in the stubble, weather conditions, and time availability have a marked influence on whether or not the land is tilled in the fall.

Spring tillage is determined by what occurred the preceeding fall and the condition of crop residues. If considerable straw is present in the spring, most growers use a disk to chop up and incorporate the



Two fallowing programs: top – straw incorporated, little or no residue on surface; bottom – straw left on the surface, no incorporation.

straw. On some occasions, a disk is required to plow under a heavy volunteer crop. When residues or a volunteer crop are not a problem, a chisel plow is used.

Following the review of the various programs used by growers, four combination fall-spring treatments were selected as being typical (Table 1). The field study to evaluate these practices was initiated in the fall of 1965 at the Bluecreek Farm with large enough plots to permit the use of standard field equipment. Each tillage plot was split to provide for a nitrogen treatment subplot. Nitrogen fertilizer in the form of ammonium nitrate was either placed with the seed at time of planting or broadcast and incorporated at time of seeding. Yield data were collected from each plot and protein content was measured on grain samples. Precipitation shown in Table 2 varies from 24.6 to 46.4 cm (9.7 to 18.3 inches) per year during the study period.

Table 1. Tillage treatments used in Bluecreek study

Tillage Treatments		
	Fall	Spring
1.	None	Disk
2.	Disk	Chisel
3.	Chisel	Disk
4.	None	Chisel

The results of the 7-year study are listed in Tables 3 and 4. The wheat yields and protein content were not significantly affected by the different tillage programs. Nitrogen fertilizer increased yields on an average of 2.4 bushel per hectare (6 bushel per acre) and protein content 1.7 percentage points. No interactions were measured between til-

lage treatments and nitrogen fertilizer. The yield variations between years generally reflect the rainfall patterns during the period.

Table 2. Annual precipitation at Bluecreek Experiment Farm October 1 through September 30, 1965-1972

Year	Inches
1965-66	9.7
1966-67	15.8
1967-68	14.6
1968-69	11.9
1969-70	13.6
1970-71	18.3
1971-72	10.0
Average	13.4

Differences

During the study a number of differences were observed and measured that did not affect the final wheat yields. Where residues were not incorporated (#4), the excess straw caused considerable difficulty during summer rod weeding. A skew treader was required ahead of seeding to avoid plugging the drills. Weed growth during the summer fallow was most pronounced on plots with large amounts of surface residue. This condition resulted from moisture being retained near the soil surface in the shade of the straw. If weather conditions had been appropriate, it is likely that moisture retention under the straw would have been adequate for the germination of wheat seeded in September. These conditions existed on occasions but fall rains erased any possibility of measuring differences among plots with and without straw mulches.

The timing of a tillage operation often appeared more important than what implement was used

Table 3. The yield of winter wheat in bushel per acre at Bluecreek as influenced by tillage and nitrogen treatments

No Nitrogen							
Treatment	67	68	Year		71	72	Ave.
			69	70			
1	32	39	39	28	30	25	32.1
2	28	36	40	28	34	27	32.1
3	30	41	39	29	34	28	33.5
4	30	37	34	29	33	27	31.7
Average	30	38	38	29	33	27	32.5

35 lbs of Nitrogen							
Treatment	67*	68	Year		71	72	Ave.
			69	70*			
1	43	41	44	32	40	28	38.0
2	39	45	43	34	43	30	39.0
3	38	47	46	34	47	30	40.3
4	38	41	40	32	43	29	37.2
Average	40	43	43	33	43	29	38.5

*50#N.

Table 4. The protein content of winter wheat at Bluecreek as influenced by tillage and nitrogen treatments

No Nitrogen							
Treatment	67	68	Year		71	72	Ave.
			69	70			
1	11.1	8.9	—	9.5	8.6	11.1	9.8
2	11.7	8.8	—	9.5	8.3	10.8	9.8
3	11.2	8.9	—	9.8	8.7	10.8	9.9
4	11.2	9.0	—	9.8	8.3	10.7	9.8
Average	11.3	8.9	—	9.7	8.5	10.9	9.8

35 lbs of Nitrogen							
Treatment	67*	68	Year		71	72	Ave.
			69	70*			
1	12.2	9.6	—	12.8	9.5	13.5	11.5
2	12.6	9.4	—	12.2	9.7	13.4	11.5
3	12.3	9.2	—	12.8	9.6	13.5	11.5
4	12.1	8.5	—	13.3	10.0	13.1	11.4
Average	12.3	9.4	—	12.8	9.7	13.4	11.5

*50#N

Considerable evidence was found that the timing of a tillage operation was often more important than what implement was used. Although plot size did not allow for runoff measurements, runoff and erosion were not problems.

In summary, the data collected suggest that the tillage programs

being used by growers in northern Utah are all equally effective. The practice selected should be directed toward the specific problem to be solved.

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Fourwing Saltbush for Land Rehabilitation in Iran and Utah

M. R. Moghaddam and C. M. McKell

Transplanting fourwing saltbush (*Atriplex canescens*) [Pursh.] Nutt. may become a popular way to restore depleted arid and semiarid rangelands. Experiences with the method in Iran and Utah hold promise for some disturbed land rehabilitation problems in Utah. Plant height at the time of transplanting appears to be a determining factor in the survival of transplants.

The Situation in Iran and Utah

Insufficiency of forage on Iranian rangelands seriously hinders livestock and meat production (Pabot 1967). Fourwing saltbush, a potential solution, is high in protein, palatable, productive, and highly adapted to arid lands. Because of often unfavorable conditions for seedling establishment, however, direct seedling of fourwing saltbush in Iranian arid lands cannot be recommended (Moghaddam 1973). In contrast, transplantation of young nursery-grown plants directly onto



the native rangelands has produced favorable results on many arid and semiarid sites ranging from sea level to 1900 m (6234 ft) in altitude and from 150 mm (5.9 in) to 400 mm (15.7 in) in annual precipitation.

Aldon (1970, 1972) has reported successful planting of fourwing saltbush in the southwest United States. And, in the US, the plant could help feed wildlife as well as livestock because of its availability and persistence during the winter (Plummer et al. 1966, 1968).

The amount of plant growth at the time of transplanting can be an important factor in obtaining maximum transplant survival. Too much top growth may put an unnecessary

transpiration burden on the seedling root system, while insufficient top growth may not support the photosynthate needs of the plant.

Study Area in Iran

Zarand Saveh is located approximately 41 km (25.5 mi) south of Karadj (76 km [47 mi] southwest of Tehran). There is no climatic station in the Zarand Saveh area, but data obtained from the nearest stations (Saveh, 70 km [43 mi] to the south and Buinzahra, 53 km [33 mi] northwest) together with the area's vegetation indicate an arid climate. The precipitation of about 150-200 mm (6-8 in.) is received mostly during the cold season of the year (see Figure 1 as adapted from Gaussen and Bagnouls 1953). Winters are

cold, with the freezing period extending from mid-November until mid-March. The summers are hot and dry.

The altitude of the research area is 1210 m (3970 ft). Soils are derived from alluvial parent materials and are brown steppic, textured lime.

The vegetation is classified a steppic type (Pabot 1967). Some of the most important plant species are: *Artemisia herba-alba*, *Salsola rigida* and *Stipa barbara*. The vegetation is in a seriously deteriorated condition due to continuous misuse by livestock during past years.

Methods and Procedures

Seeds of fourwing saltbush were planted in greenhouse flats and irrigated two times per day until they reached 3-4 cm (1-1.6 in) in height. The irrigation procedure was then continued once a day until transplantation into plastic bags. At this time (90 to 100 days after planting) plant heights were measured.

In the field, seedlings were planted in holes 4 x 4 x 4 cm (3.1 cubic in) between furrows made at 3 m (9.8 ft) intervals. All furrows and plants were numbered. After transplanting, seedlings were irrigated from a water tank once. At the end of the summer, plant survival was observed and heights again recorded.

Success in Medium Sizes

Very short or very tall seedlings did not survive transplantation. Survival was best among plants 8 to 25 cm (3.1 to 9.8 in) tall. Survival was 100 percent among plants ranging between 13 and 23 cm (5 and 9 in).

Successful establishment of fourwing saltbush by transplanting will enable range technicians to avoid the hazards of trying to obtain seed germination and establishment under extreme and uncertain

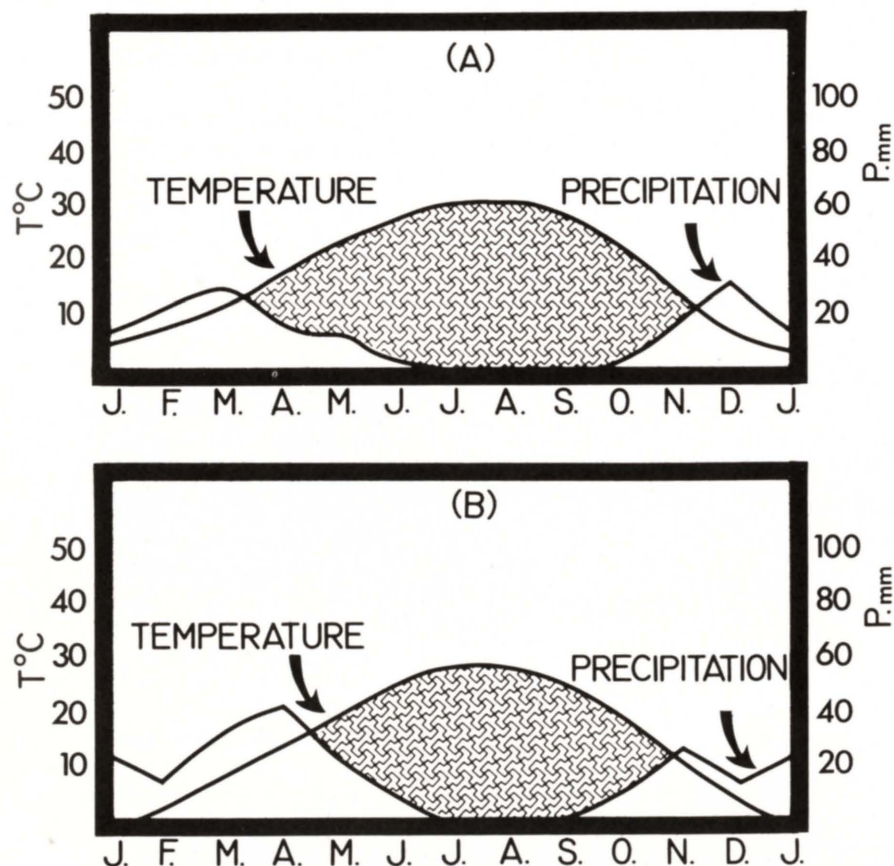


Figure 1.

Pluvio-thermic diagrams for two stations representative of the Zarand Saveh region, Iran. A = Saveh station; B = Buinzahra station.

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weather conditions. A regular and homogeneous stand of fourwing saltbush can thus be assured on depleted range sites, thereby increasing rangeland productivity and soil protection.

In Utah, projected energy resource developments, plus expected roads and industrial site construction in areas of low rainfall and high temperatures present a formidable challenge for revegetation. Efforts to seed introduced and exotic grasses on harsh sites, have met with little success.

Recent work in transplanting containerized fourwing saltbush on disturbed sites in Uintah County confirms the results obtained in Iran. Here, container-grown plants about 13 cm (5 in) tall were transplanted in April 1975. By August 15 the survival rate was 95 percent and the plants averaged 40 cm (15.7 in) in height.

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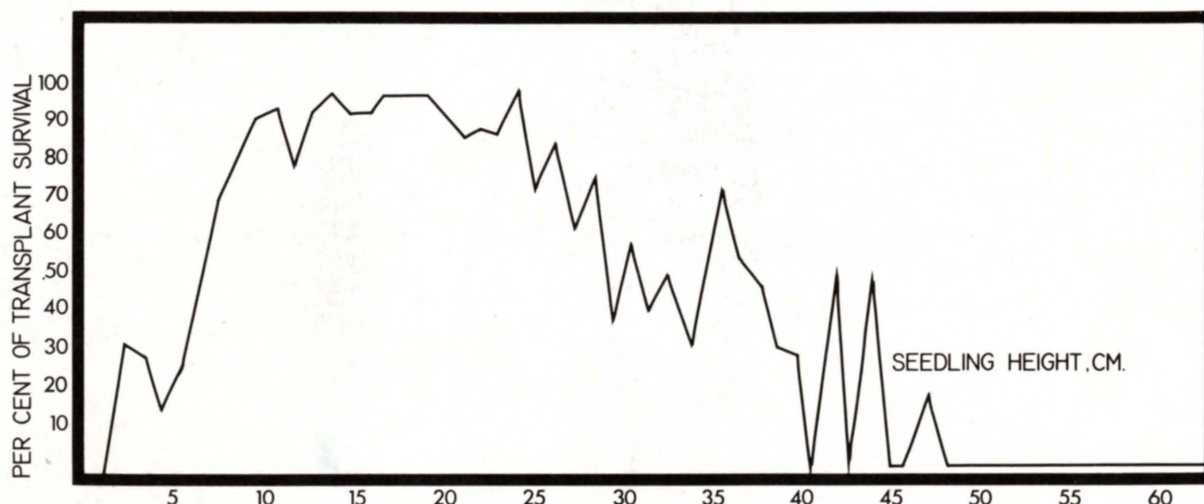


Figure 2. Survival of Fourwing Saltbrush transplants in relation to height at time of transplanting.